River Terraces and Gentle Slopes along the Shokotsu River, Northeastern Hokkaido

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Tatsuo WAKÔ

1. Preface

In the northeastern part of Hokkaido, the rivers flowing in the Sea of Okhotsk have their sources in the Kitami Range which runs from northwest to southeast in this area, and cut their channels on its northeastern slope as consequent rivers.

The geology of the range and its foreland is of complex structure composed of the rocks of the Hidaka group (pre-Cretaceous), Neogene Tertiary sediments and intruded or extruded volcanic rocks. Among them the rocks which are distributed most extensively, and closely related to the rivers throughout their courses are those of the Hidaka group which in this area consists of slate, black sand-stone and siltstone.[1)]

So far, the geological survey of Hokkaido has been carried on more extensively than in other areas, of Japan. Generally speaking, this area has been stable compared with the other areas of Japan where the crustal movements have taken place more frequently throughout the Quaternary period.

This area, therefore, is suitable for the classification and correlation of terraces. Moreover, many geological and archaeological surveys are here in progress from the viewpoint of the Quaternary research.

The author has made geomorphological survey of this area since 1958. In this paper, he describes the geomorphology of the terraces and the relating features along the Shokotsu River.

2. Description of Terraces

The author has classified the terraces into five, and named them terraces I, II, III, IV and V respectively.

The classification is based on the relative heights of terrace surfaces and those of the bases of terrace deposits, as well as on the nature of terrace deposits and continuity of terrace surfaces. The surface of terrace IV is very well preserved, and it will be convenient to use it as the key surface. Recently in Japan, the stratigraphic and mineralogical resarches of volcanic ashes have been carried on very successfully, and much has been done for the identification and classification

* Field survey was carried out under the Grant in Aid for Basic Scientific Research of Hokkaidô, 1960.

1. Geological Survey of Hokkaidô (1958): Geological Map of Hokkaido-1 : 200.000.

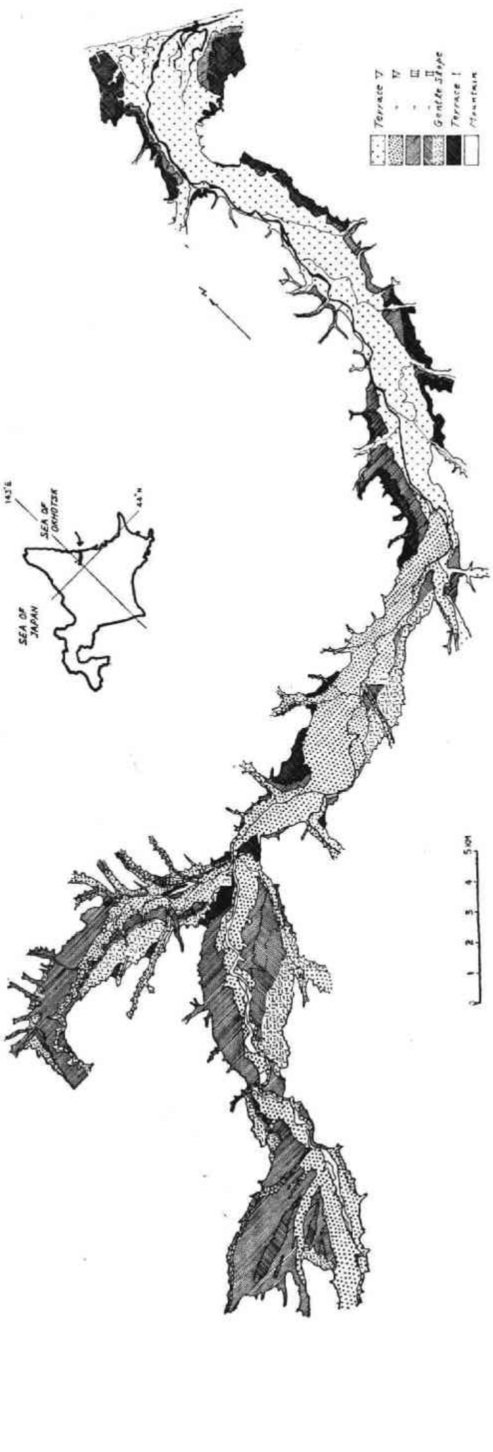


Fig. 1. River terraces and gentle slopes along the Shokotsu River.
1·2·3 — Locality numbers of sections.

of terraces, but unfortunately here we can find no ash to make the correlation.

The deposits of respective terraces are characterized as follows:

Terrace I: This is the heighest and evidently the oldest terrace that retain their surfaces in the present area. The terrace-scarps are sometimes obscure and the outcrops showing the structure are not abundant. The continuity of the profile of terrace patches is relatively good, and its identification is supported by the study of relative heights. As for its structure, this is a cut-terrace in the upper valley (Fig. 2–A), although it remains as a question whether the pathes in the lower valley also represent cut-terraces or built ones.

The geological reports hitherto have explained that these patches of the terrace in the lower valley are constructed of Neogene Teirtary sediments as undermass, and terrace deposits as overmass. However, the undermass does not appear at least near the river mouth, but there appear loose sediments, which look like terrace deposits, even as the undermass of terrace III (Fig. 2–C).

The upper layers of terrace I seen at the outcrops consist of limonite-coated gravel, laminated tuffaceous sand, and clay. All of them are cross-bedded and coarse particles are slightly cemented with limonite. Sediments seen as the undermass of terrace III resemble to those of the upper part of terrace I in their lithofacies.

Judging from the present data, the author thinks that these patches are built-terraces at least at the valley sides, and their relation to the erosional parts in the upper valley may be compared to the relation between terraces IV and V stated later. If this interpretation is correct, it is not adequate to name this "terrace I" as a terrace.

Terrace II: This is the most characteristic of the terraces along the river. The terrace deposits consist of sand and gravel, and in most cases contain rock fragments and clay. The terrace surface is also characteristic.

As such characters are observed also on gentle slopes behind terrace II, the detailed description of this terrace will be made in a later paragraph.

Terrace III: The terrace deposits consist of sand and gravel spreading in fan-like shape in the upper valley, and of limonite-coated gravel with brown sand, and at several places with greyish clay. In the middle valley, they consist of greyish clay only. In the lower valley they consist of rather loose brown sand and gravel or of loose sand only. From the structure, this terrace may be called a cut-terrace. However, it must be noted that the fan-like shape of the terrace in the upper valley and the aggradational facies of terrace deposits are characteristic (Fig. 2).

Terrace IV: The terrace deposits are rather fresh, consisted of gravel and

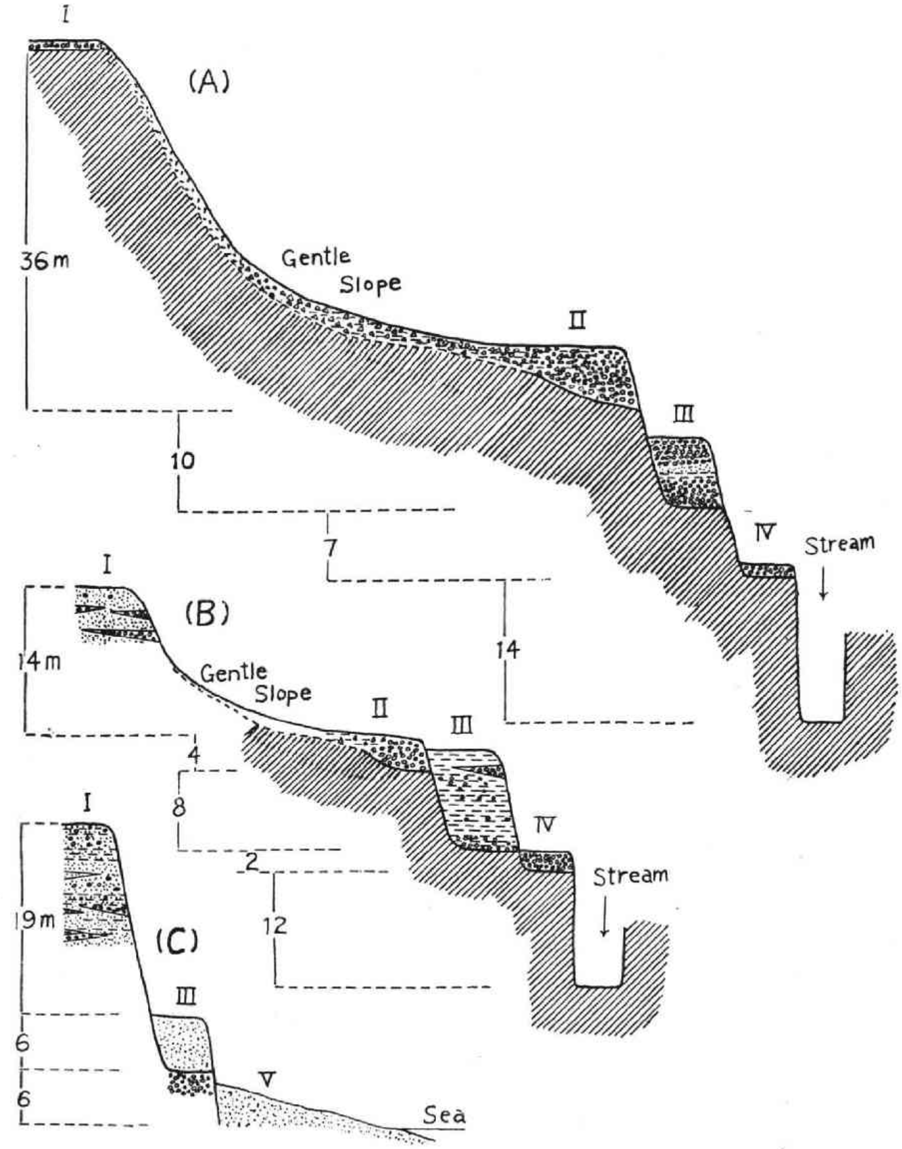


Fig. 2. Compiled cross-sections of terraces : A— the upper valley, B— the middle valley, and C— the lower valley.

sand. Seen from its structure, this is a cut-terrance covered with a "veneer" of gravel (Fig. 2). The height of the terrace-scarp increases upsteram, while the thickness of the deposits does not change on the whole throughout the course.

Terrace V: This terrace develops extensively in the lower valley and fragmentarily in the middle and upper valleys. On the surface meander scars and other fine reliefs are to be observed.

Seen from the structure this is a built-terrace in the lower valley, while in the rest it is a cut one. According to the result of boring for engineering purposses, here the thickness of the loose sediments like sand, gravel, clay, and peat exceeded 30 m. near the river mouth, without reaching to the bedrock. As described later, these deposits may be of two-cycle origin.

3. Gentle Slopes

There are characteristic gentle slopes behind terrace II, and along mountainous parts (Figs. 1, 3).

Material underlying the main part of this slope are cross-bedded clay, sand, gravel, and breccia; the last named consists of rock fragments and clay matrix, and is a chief component of this deposits. The plane of unconformity between deposits and the weathered bed-rock is obscure (Fig. 5-B, Fig. 6-A, B).

Toward the scarp of terrace II, or further from the mountain, the amount and the grain size of breccia gradually decrease, and are sometimes wholly replaced by gravel and sand. This is the "genuine terrace gravel" of terrace II. The plane of unconformity between deposits and the bed rock is distinct (Fig. 5-A).

At the foot of the mountain, breccia underlies the slope surface and the plane of unconformity is obscure (Figs. 5-C, 6-C).

There are fan-like surface forms everywhere in front of small valleys, as shown in the illustration (Fig. 3). Judging from many perfect and imperfect outcrops showing the structure of the gentle slope the thickness of deposits is larger near the foot of mountainous part and sometimes it is so thick as 10 m and it becomes thinner toward the genuine terrace part. This tendency seems to be common both in fan-like parts in front of small valleys and in parts of spur extension.

Therefore the nature of this gentle slope is not too simple. The unconformable plane between deposits and the bed-rock is uneven, as well as the surface of the slope itself.

Morphologically speaking, the surface is characteristic in the exisistence of "knick" in its profile and of being gentle, and the development of such characteristic features is not always conditioned by the lithology of the bed rock of gentle slope and that of mountain. In addition to this, small valleys jointing to the gentle slope are different from those which are in formation at the present age in this area in the longitudinal and transverse profiles. It may be suitable to call them embayments rather than small valleys.

A

B

Fig. 3. A— Frontal view of gentle slope at the middle valley of the Plain (Akira Watanabe, 1938) on which no reference is made taken from Loc. 1. C : Cultivation on the main part of gentle

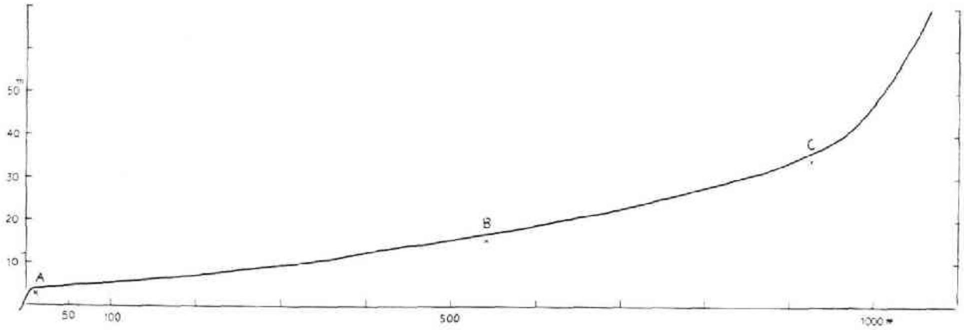
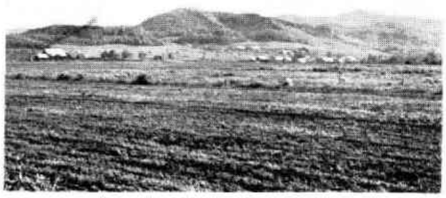


Fig. 4 : Profile of gentle slope which is drawn through Loc. 2.

Genuine terrace gravel consists of andesite, slate and others derived from the Hidaka group, as in the cases of other terraces in this area; whereas every particle of the components of the deposits underlying gentle slope is on the whole of the same lithology as the bed rock or that of adjacent mountains, excepting gravels transported from terrace I to this slope.

It is clear, therefore, that the formation of the gentle slopes is not attributable to the agency of the main stream that formed genuine terrace part. Judging from its structure, it is also clear that the formation of gentle slopes and terrace II was contemporary. As a whole this slope may be of erosional origin.



C

Shokotsu river. Higher surface shown as a sky-line is so-called Horobetsu in this report. Photo. with tele-lense. × : Loc. 1. B : Near view of slope slope, where fragmentarily paddy fields exist. 1 km. upstream Loc. 1.

4. Vertical Relations between Terraces

In this field survey, the author used 1 : 50.000 maps. It was regrettabley difficult to draw the longitudinal profile of the stream accurately based on the maps of this scale. It is also difficult to plot terrace surfaces or the basements of terrace deposits on such a diagram, especially in the cases of lower terraces. The author also explains the vertical relations between terraces from his field observation, and then compiled cross-sections of terraces (Fig. 2) :

1) Terrace IV intersects with terrace V. The bed rock underlying the deposits of terrace IV disappears at the intersecting point, and the rock can not abserved along the channel of the lower stream except where the stream has cut bluffs against the mountainous parts. Therefore the basement of the deposits of terrace IV may lie deep under the surface of terrace V. The "terrace deposits of terrace V" is not wholly deposited during the terrace V stage. The lower part must have been deposited at the time of the formation of terrace IV, whereas the upper part may be at that of terrace V. That is to say, terrace V in the lower valley is of two cycle origin, and strictly speaking this part should be called a valley plain of aggradation.

2) Upstream from this intersecting point, the stream channel has been cut into a deep trench, and the surface and the basement of deposits of terrace IV are

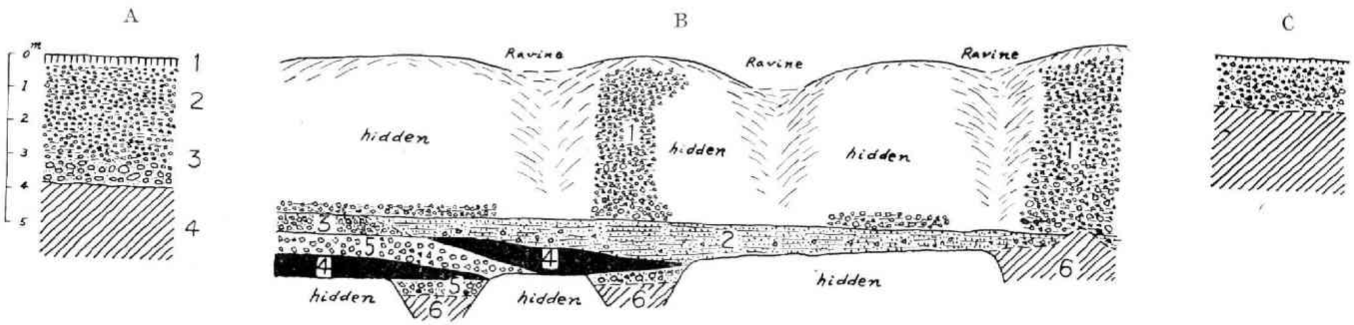


Fig. 5: Sections showing the structure of the gentle slopes in this area. Positions of each section are shown in Fig. 1, and the relative positions are checked on the profile of gentle slope in Fig. 4.

Explanation: A— Section at terrace scarp (Loc. 1), (1) Black surface soil. (2) Breccia consists of angular rock fragments with diameters of about 1 cm. and subangular fragments with diameters smaller than 5 mm., and of clay matrix. The lower part of this horizon gradually transits to gravel bed (3). This horizon is relatively compact in dry condition and plastic in wet condition. (3) Gravel bed. The upper part consists of gravel with diameters of about 3 cm. and clayey sand, and the lower part consists of gravel with diameters from 10 to 15 cm. and sand. Particles are coated and slightly cemented with limonite. (4) Bed rock, pre-Cretaceous slate.

B— Road-cut section in the longitudinal direction to the slope, a part of which is shown in Fig. 6. (Loc. 2). (1) Breccia. The upper part consists of angular and subangular rock fragments with diameters from 5 mm. to 1 cm. and of clayey matrix. The lower part looks similar to the upper part, but differs in being consisted of larger fragments with diameters of 3 cm., and being dotted with water-worn gravels with diameters of 5 cm. All particles are coated with limonite. This horizon is very compact in dry condition and into which water hardly permeates. (2) Laminated fine sand dotted with rock fragments on the right (mountain side) of this section and with gravels on theleft. Fragments and gravels are about 5 cm. in diameter and are coated with limonite. (3) Breccia dotted with gravels. Particles are coated with limonite and are about 6 cm. in diameter. Matrix is sand. (4) Black mud. (5) Gravel bed dotted with rock fragments. Particles are coated with limonite and are 5 cm in diameter. (6) Weathered bedrock (pre-Cretaceous slate). See Fig. 6.

C— Section in a cutting in a ground (Loc. 3). The structure of this part may be modified by the agency of recent mass movement of superficial layer as the genuine terrace part and even the main part of gentle slope were truncated with the stream which formed the lower terraces. (1) Black surface soil. (2) Breccia dotted with gravels. Rock fragments are 5 cm. in diameter, and gravels are from 10 to 1 cm. in diameter. Matrix is sand. Seen from the size and lithological character of each particle, it is clear that those material are derived from the bed rock. The plane of unconformity between breccia and the weathered bed rock is obscure and undulating in this section. This horizon is from 1.5 to 2.5 m. in thickness. (3) Weathered bed rock, Neogene Tertiary conglomerate. See Fig. 6.

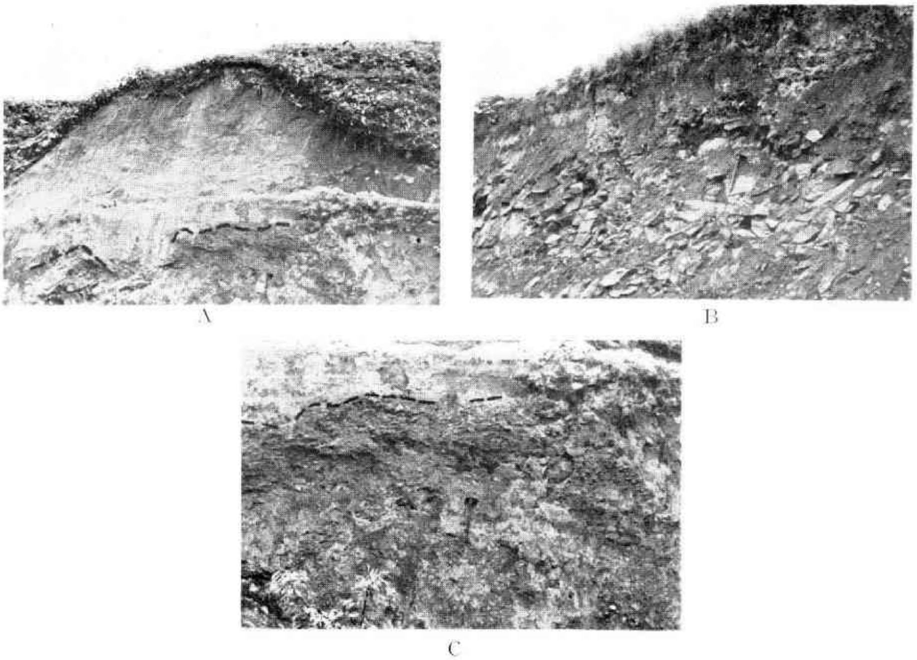


Fig. 6: A—Road-cut section shown in Fig. 5-B.
B—Detail of the part near the plane of unconformity (brocken line) in A.
C—Near view of section in a cutting shown in Fig. 5-C.
The helve of a shovel in a picture is 50 cm. long.

located higher above the present river bed. The level of the river bed and the neighbouring flood plain formed fragmentarily coincide with the surface of terrace V in the lower valley.

3) Judging from the geological sections of terrace I, relation between the upstream and the downstream parts of this terrace, both of which the writer has expressed as a terrace, may also be the same as that of terraces IV and V.

4) The surfaces of terraces II and III almost merges into a plane in the lower valley. In Fig. I such parts are shown as terrace III. Also from the heights of the basements of terrace deposits those can not be differentiated as two terraces. Nor the character of terrace deposits is convincing for classification of each terrace patch. There is not such an infilling feature as in the case of terraces IV and V. That is to say, the difference of heights of surfaces and of basements of deposits of terrace patches are not so conspicuous as one can differentiate. If there were deposits of such material as volcanic ssh, he could differentiate the terraces using them as keys.

Above mentioned relations are expressed schematically as Fig. 7.

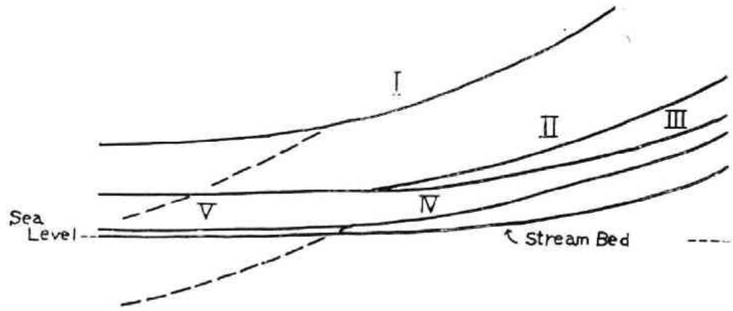


Fig. 7. Schematic longitudinal profiles of stream, terrace surfaces, and basements of terrace deposits (brocken line).

5. Summary

There are many other problems which should be taken into account, for example tectonic movements and submarine terraces. However, the author intends to discuss on such problems after having collected more data and after further research. Here he wants only to summarize the results of his observations at the present stage, for reason stated in the next paragraph.

Terrace I may be a compound terrace. That is, in the upper valley this is a terrace whereas in the lower vally is a terrace-like valley plain of aggradation with deposits corresponding to those of the terrace I. The terrace II and terrace III coincide each other. Terrace IV and terrace V intersect each other and, strictly speaking, the latter in the lower valley is an aggraded valley plain.

Therefore, there are vertically cyclic relations between terraces. Moreover, at the stage of the formation of terrace II, there developed the gentle slopes.

The author thinks that such terrace relation may be attributed to the eustatic movement of the ocean level as well as tectonic movements (upheavals of the upper course area), nevertheless the latter elements are not discussed and perhaps it is impossible to distinguish whether the influence, if there was any, was by the former or the latter. It is suggested that the development of gentle slope necessarilly took place when the ocaen level was low.

The author will continue to publish reports on the Yubetsu and the Tokoro rivers, both situated to the southeast of the Shokotsu river. Along the Yubetsu, there are the same gentle slopes as here[2], and there the absolute age of terrace deposits correlated to those of terrace III of the Shokotsu is in measurement using C^{14} method. Along the middle and upper courses of the Tokoro, there are dis-

2) Wakô, Tatsuo (1959): Gentle slope of the Yubetsu valley. Report at the annual meeting of Association of Japanese Geographers at Fukushima City.

tributed welded tuff and pumice-tuff (pumice flow deposits), as well as terraces and gentle slopes[3].

The author thinks that such geological and geomorphological studies may establish the Quarternary chronology and may suggest the morphogenetic processes in this region.

3) Wakō, Tatsuo (1961) : Relative age of formation of gentle slopes of erosional origin. Report at the symposium of Japan Association of the Quaternary Research at Tokyo.